PATENT ABSTRACTS OF JAPAN

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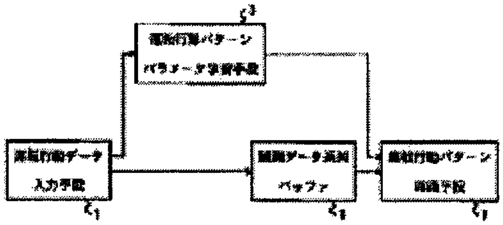
(54) DRIVING PATTERN RECOGNIZING DEVICE



(57)Abstract:
PROBLEM TO BE SOLVED: To provide a driving pattern recognizing device capable of continuously recognizing the driving pattern.
SOLUTION: A driving pattern recognizing device comprises a driving data input means 1 to input the driving data which is the time series data including at least one of the driving manipulated variable and the vehicle state quantity, and a driving pattern recognizing means 7 which calculate the probability that the driving data stored in an observed data series buffer 5 are outputted from each driving pattern using the parameters estimated by a driving pattern parameter learning means 3 and the output probability calculation algorithm, and outputs the driving pattern of the highest output probability as the result of recognition.

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the device which recognizes the motor behavior pattern of the driver who operates vehicles.

[0002]

[Description of the Prior Art]As art of recognizing a driving action pattern, from time series data, such as a control input of the driver who operates vehicles, and vehicle state quantity, For example, "Nissan Cambridge Basic. There are Research Annual Report 1996, Nissan Cambridge Basic Research, and a method indicated to Nissan Research and Development Inc." This conventional technology driving action patterns, such as right-turn at the time of automobile operation, left turn, a braking stop, and a rain change, the category of a recognition object, It is the method of making the time series data of a self-vehicle speed, self-vehicle order acceleration, a steering angle, and steering angle speed into an observation symbol sequence, respectively, and recognizing using a maximum likelihood method based on Hidden Markov Model.
The very high right recognition rate (the number of sample data in which the right category appeared as a recognition result among the total number of sample data comparatively) is reported.

[0003]

[Problem(s) to be Solved by the Invention]In this conventional method, the time series data which started the time intervals from the start of each driving action pattern to an end and which were prepared beforehand were used at the time of recognition execution. However, in such a method, since the timing of the start of a driving action pattern and the end was not clearly given when trying to recognize in real time for example, using the successive data obtained at the time of vehicle running, there was a problem that recognition could not be performed.
[0004]This invention was made paying attention to such a conventional problem, and an object of this invention is to provide the art in which continuation recognition of a driving action pattern is possible.

[0005]

[Means for Solving the Problem]In order to solve above-mentioned SUBJECT, the invention according to claim 1, A parameter presumed by a driving action pattern parameter learning means in recognition of a driving action pattern using Hidden Markov Model, An observational data series buffer stored temporarily [in order to use driving action data of the section from a recognition execution-time point to past predetermined time as an observational data series among driving action data inputted continuously] is formed, An observation symbol sequence stored in an observational data series buffer computes probability outputted from each driving action pattern model expressed with a parameter presumed by a driving action pattern parameter learning means, It has composition which establishes a driving action pattern recognition means which outputs the highest driving action pattern of an output probability as a recognition result.
[0006]Two or more observational data series buffers with which the invention according to claim 2 differs in time length, Calculation of probability that each driving action pattern will be outputted is performed using an observational data series stored in at least one or more buffers with which time length differs, and it has composition which establishes a driving action pattern recognition means which outputs the highest driving action pattern of an output probability as a recognition result.

[0007]The invention according to claim 3 has composition which forms a means to set up time length of an observational data series buffer with variable.

[0008]The invention according to claim 4 has composition which sets up time length of said observational data series buffer with variable according to traveling conditions, such as vehicles speed.

[0009]Hereafter, an operation of this invention is explained. By storing the last predetermined time section in a buffer temporarily from a recognition execution-time point among driving action data obtained continuously in the invention according to claim 1, When an observational data series used for recognition has composition including a start [of a driving action pattern], and end time, a driving action pattern using driving action data whose start [of a driving action pattern] or end time is not explicit can be recognized continuously.

[0010]In the invention according to claim 2, two or more observational data series buffers with which time length differs are formed, Calculation of probability that driving action data will be outputted from each driving action pattern model, Since it had composition which carries out using an observational data series stored in at least one or more buffers with which time length differs, and outputs the highest driving action pattern of an output probability as a recognition result, Also when average-number-of-hours length from a start of a pattern to an end differs between driving action patterns made into a recognition object, it enables it to recognize a driving action pattern more appropriately.

[0011]Continuation recognition of a driving action pattern enables it to carry out more appropriately in the invention according to claim 3 by having composition which has a means to set up with variable time length of at least one or more observational data series buffers who provides in order to use for calculation of an output probability of each driving action pattern.

[0012]Time length of said observational data series buffer enables it to carry out more appropriately [continuation recognition of a driving action pattern] in the invention according to claim 4 by considering it as variable according to traveling conditions, such as the vehicle speed.

[0013]

[Embodiment of the Invention]Hereafter, the embodiment of the driving action pattern recognition device by this invention is described in detail with reference to an accompanying drawing.

[0014](A 1st embodiment) A 1st embodiment of the driving action pattern recognition device by this invention is described using drawing 1 - drawing 4. The block diagram in which drawing 1 shows the outline composition of a 1st embodiment, and drawing 2 are the block diagrams showing the functional constitution of a 1st embodiment.

[0015]First, composition is explained using drawing 1. The driving action data input means 1 which inputs the driving action data which is time series data of the amount of operation, and vehicle state quantity which contain either at least, The driving action pattern parameter learning means 3 which uses the driving action data of each driving action pattern for an observation symbol sequence, and presumes the amount of statistical features required in order to express each driving action pattern made into a recognition object as Hidden Markov Model, The observational data series buffer 5 which stores said driving action data of the latest predetermined time section from a recognition execution-time point, The probability that the driving action data stored in the observational data series buffer 5 will be outputted from each driving action pattern, It computes using the parameter and output probability calculation algorithm which were presumed by the driving action pattern parameter learning means 3, and has composition which has the driving action pattern recognition means 7 which outputs the highest driving action pattern of an output probability as a recognition result.

[0016]Hereafter, it explains as an example for describing the embodiment in this invention supposing the recognition system which recognizes five kinds of driving action patterns, right-turn, left turn, a braking stop, a lane change, and passing. Among these, since the lane change can consider two kinds of lane changes to the lane on the right-hand side of a self-vehicle, and the lane on the left-hand side of a self-vehicle, it decides to treat as another driving action pattern. Therefore, recognition of six kinds of driving action patterns is considered.

[0017]Driving action data is data, for example, concerning driving action, such as a self-vehicle speed and self-vehicle order acceleration, considering an accelerator pedal opening and a steering angle as vehicle state quantity as a driver's control input, for example, and these are measured with the various sensor 11. The recognition system of the driving action pattern using Hidden Markov Model is built using the computer 13. The recognition process of Hidden Markov Model can roughly be divided into the recognition using the parameter presumed to be presumption of a parameter. According to a 1st embodiment, in the computer 13, the former shall be the parameter estimation treating part 15, the latter shall be the recognizing processing part 17, and processing shall be performed, respectively.

[0018]In order to perform the pattern recognition of time series data using Hidden Markov Model, it is necessary to presume parameter lambda[of the category beforehand made into a recognition object] = {pi, A, B}. Here, pi shows an early embryogenesis probability set of each state, A shows the transition probability set between states, and B shows an output probability set, respectively. After being classified according to the driving action pattern made into a recognition object according to the pretreatment part 19, the driving action data obtained with the various sensor 11 is stored in the driving action data storage memory 21, and is used as an observation symbol sequence.

[0019]As opposed to each driving action pattern which is a recognition object in the parameter estimation part 23, The initial probability pi which is a parameter of Hidden Markov Model, the transition probability A between states, and the output probability B are presumed that the probability P (lambda|O) outputted from driving action data becomes the maximum using the observation symbol sequence of a large number stored in the driving action data storage memory 21.

[0020]A Baum-Welch algorithm is generally used for the parameter estimation of Hidden Markov Model. A Baum-Welch algorithm and the Forward algorithm mentioned later, and a Viterbi algorithm, For example, Document "X.D.Huang, Y.Ariki, and and. M.A. The contents are known by Jack.Hidden Markov Models for Speech Recognition. Edinburgh University Press, Edinburgh, and 1990." A driving action pattern is recognized using the parameter of the Hidden Markov Model obtained in the above procedure. The presumed parameter is memorized in the parameter storing memory 25.

[0021]The driving action data of the section of the last predetermined time section T is temporarily memorized from the recognition execution-time point by the observational data series buffer 27 at the memory. In the driving action pattern recognition execution part 29, the Forward algorithm which is an output probability calculation algorithm of Hidden Markov Model, or a Viterbi algorithm is used, Using the parameter presumed to be an observation symbol sequence in the above-mentioned driving action data, the action probability P of each driving action pattern (O|lambda) is computed, and it outputs to the memory 31 for a recognition result output by making a driving action pattern with the highest output probability into a recognition result.

[0022]Next, the manipulation routine in the recognizing processing part 17 is explained. After recognizing processing part 17 starting, if the interrupt signal generated for every sampling period Ts using an interruption timer is detected at Step S101, the observational data series buffer 27 will be updated. Here, a buffer is made into sampling period Ts, sampling-data number m, and buffer length L seconds for explanation.

[0023]First, it moves at a time back one data currently stored in the buffer at Step S103. Next, the signal outputted from the sensor is read via an A/D conversion at Step S105, and it writes in at Step S107. By performing this operation for every sampling period, the driving action data for L last seconds is always held from a recognition execution-time point at a buffer.

[0024]As an example of correspondence of the driving action data and the data series buffer in a 1st embodiment, the example of data at the time of right-turn is shown in drawing 4.

[0025]Next, if the interrupt signal below which it interrupts similarly and which is generated for every recognition execution cycle Tc using a timer is detected at Step S109, at Step S111, the output probability P of each driving action pattern (O|lambda) will be computed, and let a driving action pattern with the highest output probability be a recognition result. A recognition result is Step S113 and is stored in the memory for a recognition result output.

[0026](A 2nd embodiment) A 2nd embodiment of the driving action pattern recognition device by this invention is described using drawing 3 and drawing 5.

[0027]According to a 2nd embodiment, two or more different time length's buffers are formed. As an example for explanation, n buffer O_1 - O_n are provided to six kinds of above-mentioned driving action patterns.

[0028]The renewal of a buffer at Step S103 in the process flow (refer to drawing 3) of the recognizing processing part 17 and the writing to the buffer of the data in Step S107 are performed to each buffer O_1 - O_n. Calculation of an output probability computes output probability P_{ij}=P (O_j|lambda$_i$) using at least one or more buffer O_j corresponding to the driving action pattern i. At this time, O_n which sets up the average-number-of-hours length of a driving action pattern etc. which used the time length of buffer O_j for parameter estimation so that the optimal recognition performance for reference may be obtained is provided. Correspondence with buffer O_j which each recognition category lambda$_i$ uses is defined beforehand, and gives the contents to the recognizing processing part 17.

[0029]The example of correspondence of the driving action data and the data series buffer in a 2nd embodiment is shown in drawing 5.

[0030](A 3rd embodiment) A 3rd embodiment of the driving action pattern recognition device by this invention is described using drawing 6 - drawing 8. Drawing 6 is a block diagram showing the outline composition of a 3rd embodiment, and a different point from 1st and 2nd embodiments is a point of having formed the data series buffer length variable setting-out means 9. Drawing 7 is a block diagram showing the functional constitution of a 3rd embodiment, and a different point from 1st and 2nd embodiments is a point of having newly formed the operation switch treating part 43 which processes the contents of operation of the switch 41 and the switch 41.

[0031]Drawing 8 shows the process flow in the recognizing processing part 17a. Starting of the recognizing processing part 17a will carry out initial setting of the buffer length to default value at Step S201. If operation of a switch of specifying the buffer length is detected at Step S203, at Step S205, the contents of operation will be detected and Step S207 will perform the re set of the buffer length of the buffer which is a change target. Since it is the same processing as the flow shown in drawing 3 henceforth, explanation is omitted.

[0032]As a concrete example of the switch 41 in a 2nd embodiment, it is usable in the DIP switch on the computer 13, exchange of ROM mounted in an electronic circuit, variable-value setting out of the software for recognition execution, etc.

[0033](A 4th embodiment) A 4th embodiment of the driving action pattern recognition device by this invention is described using drawing 9 and drawing 10.

[0034]At the time of recognition execution, it can be said that it is desirable when it raises recognition precision that the time series data contained in a buffer do not contain the data of a different driving action pattern before a start and after an end, certainly including the time intervals from a certain driving action pattern start to an end.

[0035]However, since two or more categories are made into a recognition object in the usual recognition system, it is possible that the average-number-of-hours length from the start of a driving action pattern to an end may differ between categories. According to a 4th embodiment, the memory which can be mounted in the computer 13 has restrictions, and when the buffer of sufficient number cannot be set up, it aims at enabling it to perform recognition with more sufficient recognition precision by setting up the buffer length with variable according to a traveling condition.

[0036]The example using the identification method using Image Processing Division of the vehicle front situation as an example of such an embodiment is explained. It carries out [that whether the crossing is approached on the street way or a highway is under run can judge, and] by carrying out Image Processing Division of the picture which photoed the vehicle front situation on a computer, and recognizing a traveling condition.

[0037]Drawing 9 is a block diagram showing the functional constitution of a 4th embodiment, and different points from the 1st - a 3rd embodiment are the imaging device 51, the image processing device 53, and a point of having newly formed the traveling condition judgment part 55.

[0038]Image Processing Division of the image data inputted from the imaging device 51 is carried out with the image processing device 53, and the judgment of a traveling condition is performed by the traveling condition judgment part 55. When judged with it crossing being under approach by the traveling condition judgment part 55, When judged with the buffer length set as the recognition execution part 17b highway being under run again near [average-number-of-hours length] the driving action pattern of right-turn or left turn, the buffer length is passed or it resets near [average-number-of-hours length] a rain change, respectively.

[0039]Drawing 10 shows the process flow in the recognizing processing part 17b. In Step S301, a traveling condition and the buffer length's contents of correspondence are read, and initial setting is performed. A traveling condition recognition result is inputted in Step S303. In Step S305, the existence of traveling condition change is judged from the decision result from the traveling condition judgment part 55. When traveling condition change arises, it changes into the buffer length corresponding to the judged traveling condition at Step S307. Since it is the same processing as the flow shown in drawing 3 henceforth, explanation is omitted.

[0040]As mentioned above, although this invention was concretely explained based on the embodiment, it cannot be overemphasized that it can change variously in the range which this invention is not limited to said embodiment and does not deviate from the gist.

[0041]

[Effect of the Invention] As mentioned above, since it had composition which recognizes a driving action pattern using the driving action data of the last predetermined time section from a recognition execution-time point in recognition of the driving action pattern using Hidden Markov Model according to this invention as explained in detail, continuation recognition of a driving action pattern is possible.

CLAIMS

[Claim 1]A driving action data input means which inputs driving action data which is time series data of the amount of operation, and vehicle state quantity which contain either at least, A driving action pattern parameter learning means which uses driving action data of each driving action pattern for an observation symbol sequence, and presumes the amount of statistical features required in order to express each driving action pattern made into a recognition object as Hidden Markov Model, An observational data series buffer which stores said driving action data of the latest predetermined time section from a recognition execution-time point, Driving action data stored in said observational data series buffer probability outputted from each driving action pattern model expressed with a parameter presumed by said driving action pattern parameter learning means, A driving action pattern recognition device having a driving action pattern recognition means which computes using an output probability calculation algorithm and outputs the highest driving action pattern of an output probability as a recognition result.

[Claim 2]Two or more observational data series buffers which differ in time length in the driving action pattern recognition device according to claim 1, As a Hidden-Markov-Model observation symbol sequence used for output probability calculation of each driving action pattern, A driving action pattern recognition device having a driving action pattern recognition means using an observational data series buffer set up to a driving action pattern used as a calculation target out of said at least one or more observational data series buffers.

[Claim 3]A driving action pattern recognition device having a data series buffer length variable setting-out means to set up time length of said observational data series buffer with variable, in the driving action pattern recognition device according to claim 1 or 2.

[Claim 4]In the driving action pattern recognition device according to any one of claims 1 to 3, A driving action pattern recognition device having a data series buffer length variable setting-out means to judge a traveling condition of self-vehicles and to set up the traveling condition data series buffer length with variable according to a traveling condition from data of vehicle running data of self-vehicles, the circumference of a self-vehicle, etc.

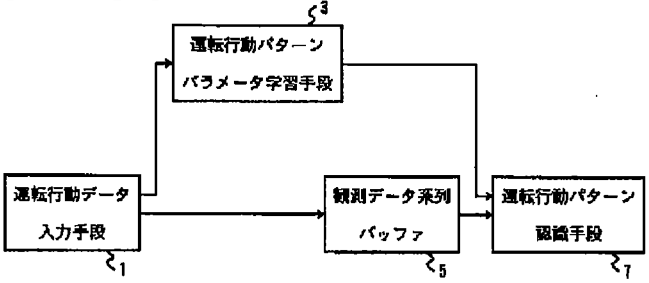
[Brief Description of the Drawings]

[Drawing 1]It is a block diagram showing the outline composition of a 1st embodiment of the driving action pattern recognition device by this invention.
[Drawing 2]It is a block diagram showing the functional constitution of a 1st embodiment.
[Drawing 3]It is a figure showing the process flow in a recognizing processing part.
[Drawing 4]It is a figure showing the example of correspondence of driving action data and a data series buffer (at the time of right-turn).
[Drawing 5]It is a figure showing the example of correspondence of the driving action data and the data series buffer which were formed.
[Drawing 6]It is a block diagram showing the outline composition of a 3rd embodiment.
[Drawing 7]It is a block diagram showing the functional constitution of a 3rd embodiment.
[Drawing 8]It is a figure showing the process flow in the recognizing processing part of a 3rd embodiment.
[Drawing 9]It is a block diagram showing the functional constitution of a 4th embodiment.
[Drawing 10]It is a figure showing the process flow in the recognizing processing part of a 4th embodiment.

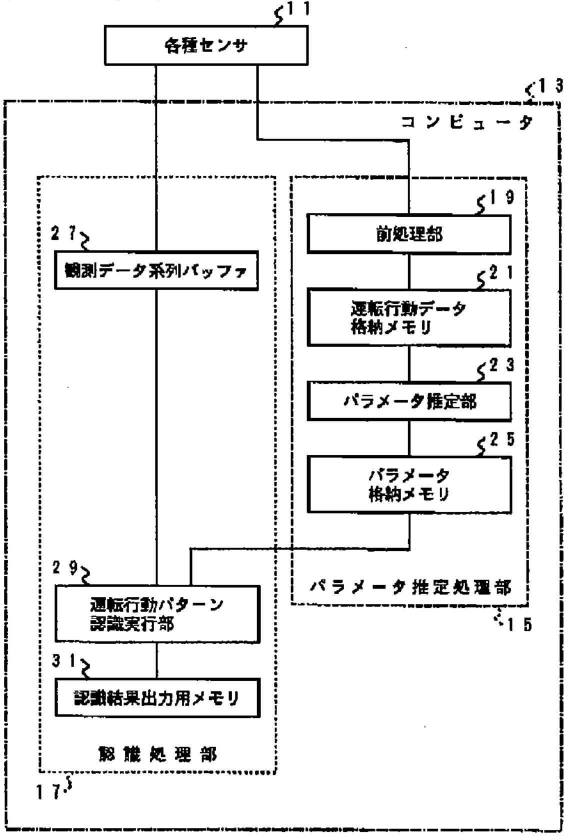
[Description of Notations]

1 Driving action data input means
3 Driving action pattern parameter learning means
5 Observational data series buffer
7 Driving action pattern recognition means
9 Data series buffer length variable setting-out means
11 Various sensor
13 Computer
15 Parameter estimation treating part
17, 17a, and 17b Recognizing processing part
19 Pretreatment part
21 Driving action data storage memory
23 Parameter estimation part
25 Parameter storing memory
27, 27a, 27b observational data series buffer
29 Driving action pattern recognition execution part
31 The memory for a recognition result output
41 Switch
43 Operation switch treating part
51 Imaging device
53 Image processing device
55 Traveling condition judgment part

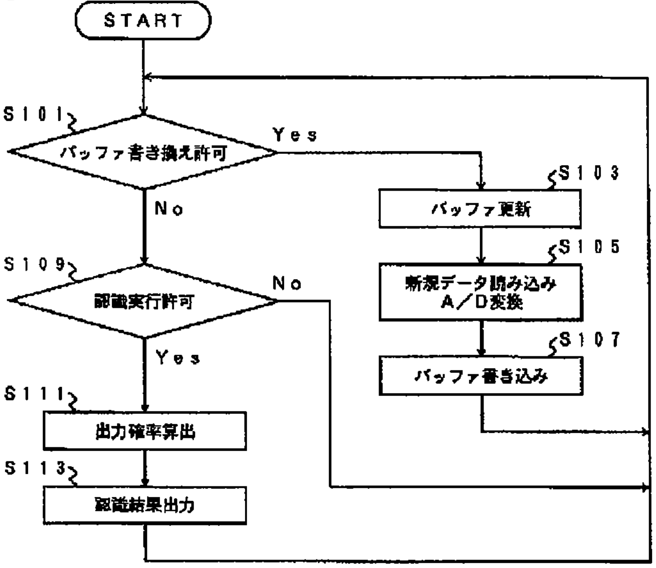
[Drawing 1]


3
運転行動パターン
パラメータ学習手段
運転行動データ
入力手段
1
観測データ系列
バッファ
5
運転行動パターン
認識手段
7

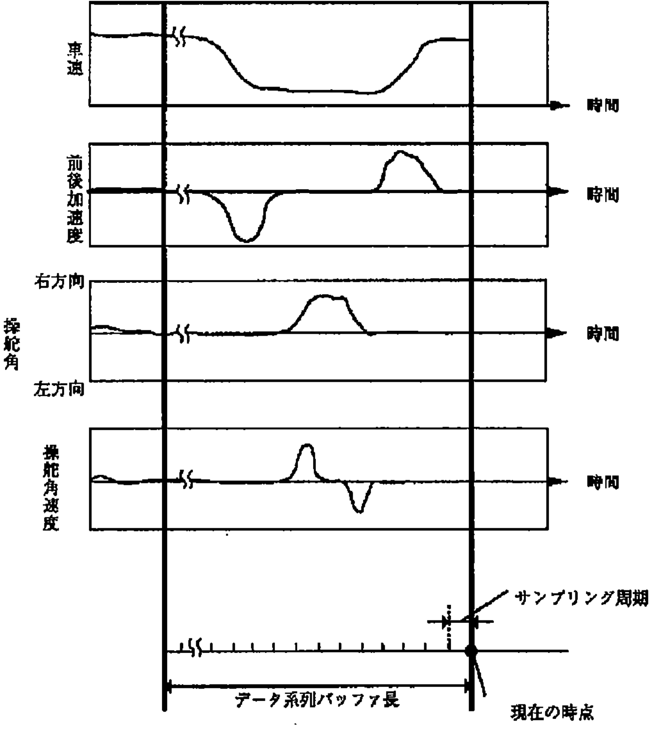
[Drawing 2]


11
各種センサ
13
コンピュータ
19
前処理部
21
運転行動データ
格納メモリ
23
パラメータ推定部
25
パラメータ
格納メモリ
パラメータ推定処理部
15
27
観測データ系列バッファ
29
運転行動パターン
認識実行部
31
認識結果出力用メモリ
認識処理部
17

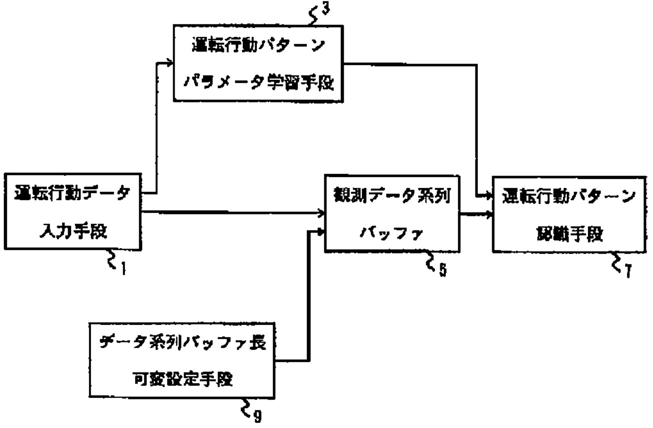
[Drawing 3]


START
S101
バッファ書き換え許可
Yes
No
S103
バッファ更新
S105
新規データ読み込み
A／D変換
S107
バッファ書き込み
S109
認識実行許可
No
Yes
S111
出力確率算出
S113
認識結果出力

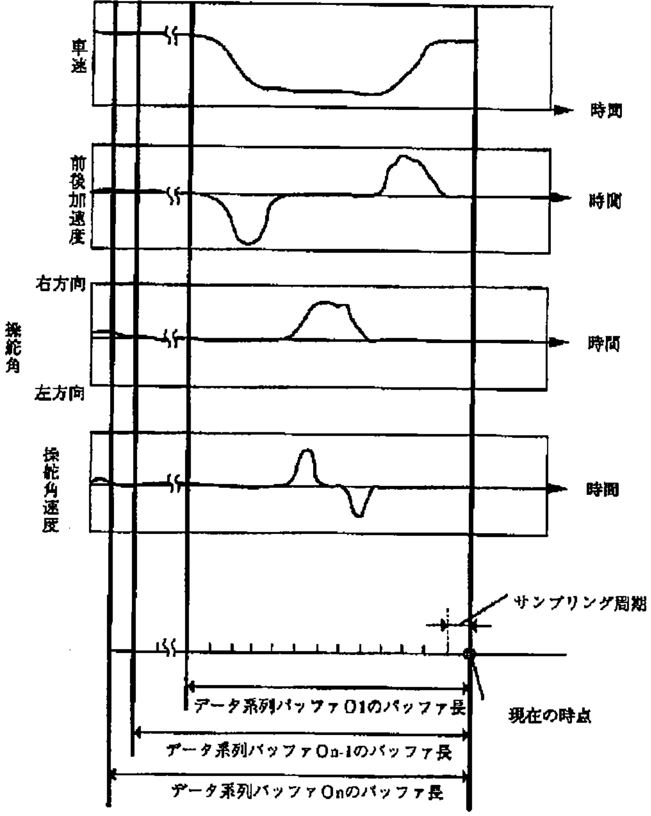
[Drawing 4]



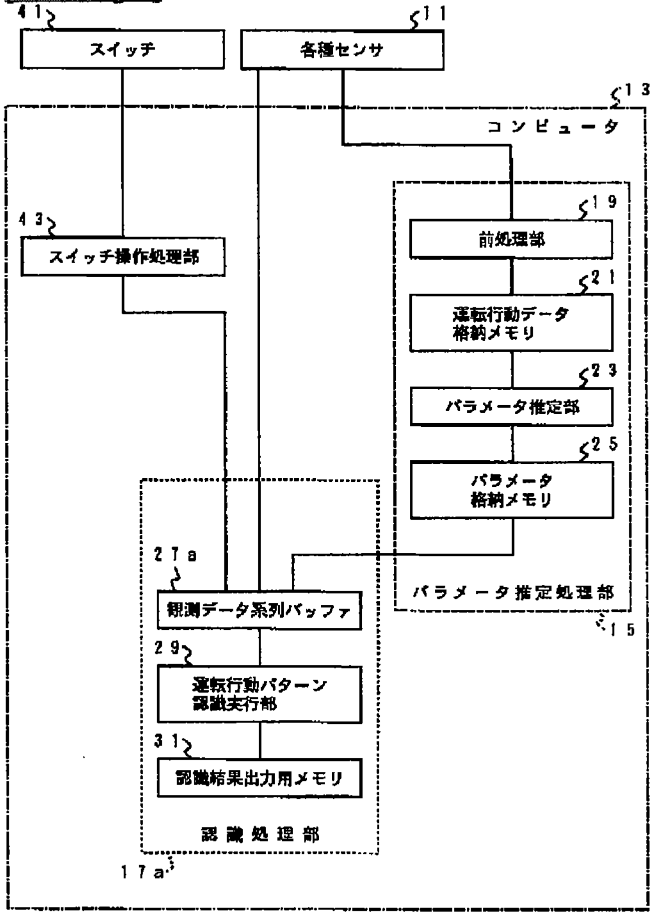
[Drawing 6]


3
運転行動パターンパラメータ学習手段
運転行動データ入力手段
1
観測データ系列バッファ
5
運転行動パターン認識手段
7
データ系列バッファ長可変設定手段
9

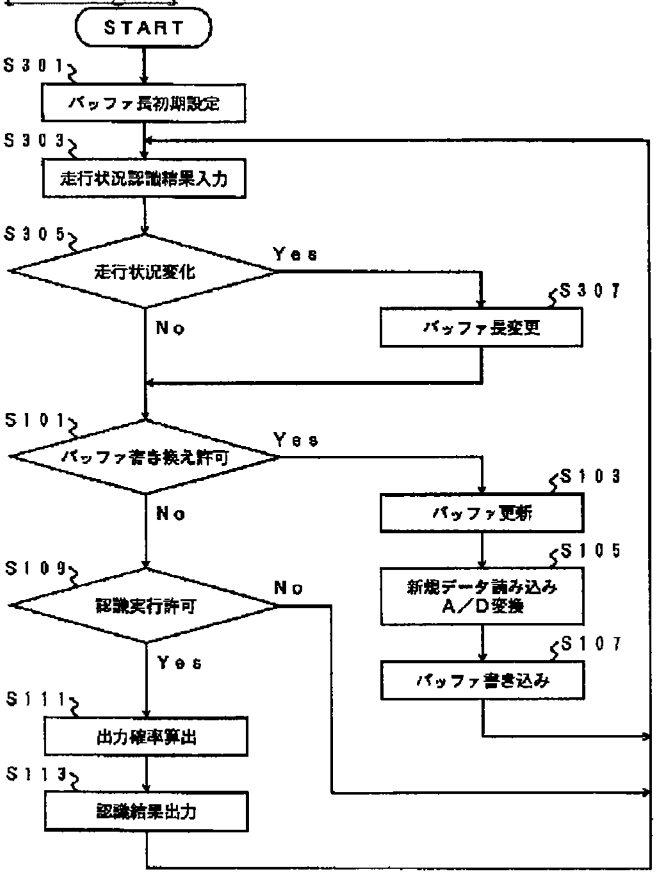
[Drawing 5]



[Drawing 7]


41
スイッチ
11
各種センサ
13
コンピュータ
19
前処理部
21
運転行動データ
格納メモリ
23
パラメータ推定部
25
パラメータ
格納メモリ
パラメータ推定処理部
15
43
スイッチ操作処理部
27a
観測データ系列バッファ
29
運転行動パターン
認識実行部
31
認識結果出力用メモリ
認識処理部
17a

[Drawing 10]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S303
走行状況認識結果入力
S305
走行状況変化
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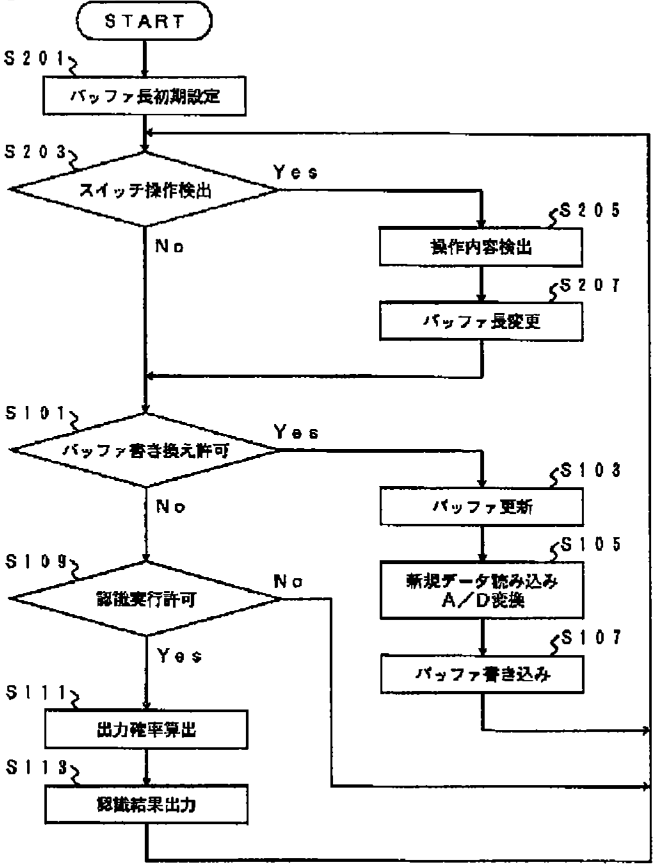
No
S307
バッファ長変更
S101
バッファ書き換え許可
Yes
No
S103
バッファ更新
S105
新規データ読み込み
A／D変換
S107
バッファ書き込み
S109
認識実行許可
No
Yes
S111
出力確率算出
S113
認識結果出力

[Drawing 8]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操作内容検出
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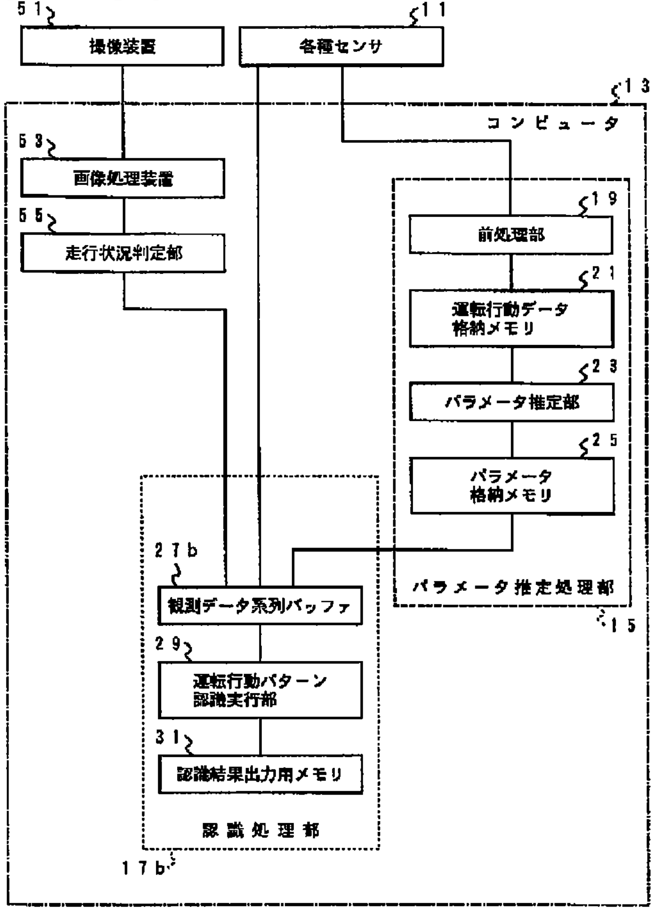
S101
バッファ書き換え許可
Yes
No
S103
バッファ更新
S105
新規データ読み込み
A／D変換
S107
バッファ書き込み
S109
認識実行許可
No
Yes
S111
出力確率算出
S113
認識結果出力

[Drawing 9]


5 1
撮像装置
1 1
各種センサ
1 3
コンピュータ
5 3
画像処理装置
5 5
走行状況判定部
1 9
前処理部
2 1
運転行動データ格納メモリ
2 3
パラメータ推定部
2 5
パラメータ格納メモリ
パラメータ推定処理部
1 5
2 7 b
観測データ系列バッファ
2 9
運転行動パターン認識実行部
3 1
認識結果出力用メモリ
認識処理部
1 7 b